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Chapter 9

Exploring the Role of Mobility and Personality for Healthy Aging

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Abstract

Both mobility and personality are key determinants of healthy aging. However, these two constructs have barely been explored in combination, although mobility and personality effects on healthy aging are expected to not be independent from another. This chapter aims at combining both perspectives and setting a foundation to foster future research, jointly investigating personality and mobility effects on healthy aging. Therefore, the chapter suggests to decompose mobility in the two components motility (i.e., the movement potential) and movement (i.e., the actual manifested mobility). This decomposition allows to draw parallels to the commonly used distinction between personality traits and states. While motility and personality traits refer to the temporally stable underlying dispositions of an individual, movement and personality states conceptualize the day-by-day manifestation of the respective construct. Drawing upon the parallels regarding the distinct levels of analysis in both domains, a conceptual model is proposed that links the individual components with healthy aging. The individual links are discussed using relevant empirical research and theories and hypothesizing potential causal pathways between mobility, personality and healthy aging.

1 Introduction

Promoting healthy aging has become a public health priority and key research endeavor due to rapidly aging populations around the world (WHO, 2015). Despite the decrease in physical autonomy with increasing age, factors such as independent living, maintaining an active lifestyle, and engaging in social interactions are key outcomes for both healthy aging and older adult well-being (Kestens et al., 2016; Schalock, Bonham, & Verdugo, 2008). Mobility, defined as where we move, how we move, with whom we move, why we move, and how often we move, has been found to be a key determinant of healthy aging (Cuignet et al., 2019; Hirsch, Winters, Clarke, & McKay, 2014; Musselwhite & Haddad, 2010; Schwanen & Ziegler, 2011). Mobile people are empowered to access resources which gives them a sense of autonomy (Banister & Bowling, 2004; Chung, Demiris, & Thompson, 2015; Musselwhite & Haddad, 2010). Traveling using active modes of transport (such as walking or cycling) reflects active lifestyles that have been found to correlate with physical health and well-being (Huss, Beekhuizen, Kromhout, & Vermeulen, 2014; Seresinhe, Preis, & Moat, 2015). Moreover, older adults who have access to a car or public transport, as well as good community facilities and services, have a greater number of social interactions and higher levels of well-being than their counterparts (Banister & Bowling, 2004; Gagliardi, Marcellini, Papa, Giuli, & Mollenkopf, 2010).

Besides mobility, individual differences in thinking, feeling, and behaving are important determinants of healthy aging (see the chapters in this book). This chapter focuses on individual differences in personality traits as dispositional tendencies and personality states as situational and momentary manifestations of traits in daily life (see Chap. 7 by Jackson & Beck in this book). In essence, personality traits are defined as relatively enduring and automatic patterns of behaviors, thoughts, and feelings (Baumert et al., 2017; Roberts, 2018) and describe the most basic and general dimensions upon which individuals are typically perceived to differ. Personality states, then, reflect the temporary manifestations of personality traits in response to both internal aspects, such as motives and goals, and external situations, such as stress in a given situation or interactions in a social context (Baumert et al., 2017; Hooker & McAdams, 2003). States reflect how individuals think, feel, or behave in a given situation or context. Individual differences in personality traits and states are often organized within the conceptual framework of the Big Five (John, Naumann, & Soto, 2008) or Five-Factor Model (McCrae & Costa, 2008) upon which this chapter is based as well. These models include five broad dimensions that are experienced on a spectrum: neuroticism (defined as the propensity to be anxious, worrisome, angry and depressed), extraversion (propensity to be sociable, active, assertive, and to experience positive affect), openness to experience (propensity to be original, complex, creative, and open to new ideas), agreeableness (propensity to be altruistic, trusting, modest, and warm), and conscientiousness (propensity to be self-controlled, task- and goal-directed, planful, and rule following).

The process of healthy aging is influenced by the interplay of a broad range of individual, environmental, and policy-based factors, amongst which personality and mobility can be placed (Sallis et al., 2006). Existing research has investigated the role of personality and mobility as independent determinants of individuals' health and well-being. In this chapter, however, we provide a theoretical framework for how mobility and personality together influence healthy aging. Little research exists in which relationships between mobility and personality have been investigated (Alessandretti, Lehmann, & Baronchelli, 2018; Chorley, Whitaker, & Allen, 2015; de Montjoye,

Quoidbach, Robic, & Pentland, 2013). And to the best of our knowledge, no research has investigated mobility-personality interrelationships and their implications for healthy aging.

This chapter aims to combine the perspectives of mobility and personality research to help advance our understanding of healthy aging. The chapter starts by disentangling the construct of mobility by examining how it is defined, operationalized, and measured. This will serve as a foundation for the second step, in which we present a conceptual model to bridge the two domains in order to explore potential causal pathways linking mobility and personality with healthy aging. The chapter is concluded by a discussion of the model and an outlook on potential future research.

2 Mobility

There is an increasing number of researchers suggesting to decompose mobility into the two components *motility* (i.e., the mobility potential) and *movement* (i.e., the actual manifested mobility) and assess them separately (**Figure 1**) (Cuignet et al., 2019; Shliselberg & Givoni, 2018; Thigpen, 2018). Motility and movement are two distinct and complementary concepts that shape an individual's mobility. In a similar fashion as how personality traits are latent and refer to an individual's personality disposition, motility is latent and refers to an individual's disposition towards mobility. Movement, on the other hand, is a context and time-dependent interpretation of mobility and thus shows parallels with the concept of personality states. Like personality traits and states, motility and movement might have differential effects on healthy aging. Both motility and movement are multidimensional concepts (dotted lines in **Figure 1**) and each dimension can further be operationalized through multiple complementary metrics that are presented in detail in the following sections. The different aspects of both motility and movement again are expected to have potentially health-beneficial or health-damaging effects.

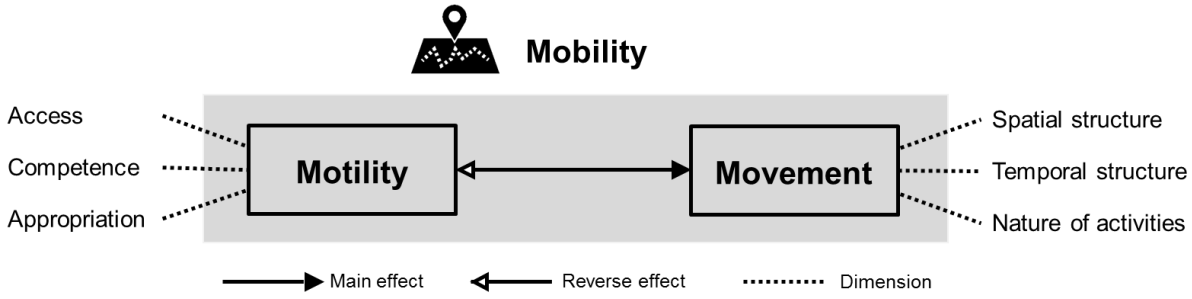

Figure 1: Mobility decomposed into motility and movement with its respective dimensions.

2.1 Motility: How People (Think They) Could be Mobile

Historically rooted in biology, the concept of motility was for the first time thoroughly introduced in the social sciences by Kaufmann (2002) and defined as the capacity of a person to be mobile, or more precisely, as the way in which an individual understands what his/her possibilities are in the domain of mobility. Three core interdependent dimensions define the concept of motility: access, competence, and appropriation (**Figure 1**) (Cuignet et al., 2019; Kaufmann, 2002; Shareck, Frohlich, & Kestens, 2014). Access refers to the surrounding environments shaping opportunities

and locations with which individuals can choose to engage. Competence subsumes physical and cognitive abilities and skills needed to exploit the mobility options (e.g., a driver's license). Finally, appropriation refers to the decision-making processes and the evaluation of mobility options. Appropriation is highly influenced by a person's movement experiences, which in turn form a person's attitude towards mobility.

There is little literature in which motility was effectively operationalized with quantitative indicators (Cuignet et al., 2019; De Vos, Schwanen, Van Acker, & Witlox, 2013; Kaufmann, Dubois, & Ravalet, 2017; De Witte & Macharis, 2010). Motility is rather stable over time, as it is composed by dimensions that are typically subject to either rare changes (e.g., life changing events such as relocation to a different residential neighborhood), or slow changes (e.g., loss of physical abilities and skills, or evolution of attitudes). Consequently, motility is either assessed using single-occasion measurements as in typical cross-sectional study designs or longitudinally to capture slow developmental change, i.e., multiple times within the same individual over large temporal intervals (e.g., 4 years in Kaufmann et al., 2017). Motility is traditionally assessed using interviews (Flamm & Kaufmann, 2006) or questionnaires (Kaufmann et al., 2017). Geographic information system (GIS) based measures can be used to proxy the access dimension of motility, by qualifying and quantifying the local accessible environmental resources within an individual's residential neighborhood. Advances in mobile sensing technologies opened up new opportunities to develop more comprehensive measures of environmental exposures over an individual's entire activity space (e.g., Perchoux, Chaix, Cummins, & Kestens, 2013) which is defined as "the subset of all locations within which an individual has direct contact as a result of their day-to-day activities" (Golledge & Stimson, 1997, p. 279). Besides self-reports, lab-based measures can be used to infer motility-relevant competences while some of the appropriation aspects can be additionally inferred from GIS-based analysis of sensed real-life mobility data.

Because of the limited attempts to quantitatively operationalize motility, a gold standard to assess the various dimensions of motility has not yet been developed. To determine a more unified method for motility assessment, we discuss exemplary indicators for each dimension of motility (**Table 1**). Access is decomposable into indicators describing an individual's personal resources (e.g., availability of a car) and environmental resources (e.g., neighborhood walkability). Accessibility indicators describing the built environments can be grouped into the 5 'D' variables (Ewing & Cervero, 2010): density, diversity, design, destination accessibility, and distance to transit. Physical and cognitive skills constituting the competence aspect of motility essentially consist of indicators that proxy how well an individual is capable of planning and executing his/her actual movements (Giannouli, Bock, Mellone, & Zijlstra, 2016). Finally, appropriation is assessable by relying on measures that proxy mobility habits and preferences such as a participant's frequency of used transport modes and attitude towards different means of transport (Cuignet et al., 2019; De Witte, Macharis, Lannoy, & Van De Walle, 2006).

Table 1: Example indicators used in the literature classified into dimensions and sub-dimensions according to the motility characteristics they represent

Dimension	Indicators
Access	
Personal access	• Car availability, home-work distance, net income (Witte & Macharis, 2010) • Internet/computer availability (Kaufmann et al., 2017)
Environmental access	• Walkability in residential neighborhood, e.g., NEWS scale (Sallis, Frank, Saelens, & Kraft, 2004) • Characterization of residential neighborhood or activity-space-based environmental access w.r.t. the 5 'D' variables of Ewing and Cervero (2010): e.g., number of amenities (density, diversity), number of road network nodes (design of network), number of public transport stops (distance), number of buses/trains (destination accessibility) (Cuignet et al., 2019) • Access to highway, regional and high-speed train, and airport (within 20, 20, and 45 min, respectively) (Kaufmann et al., 2017)
Competence	
Physical skills	• Timed up-and-go test (Giannouli et al., 2016; Podsiadlo & Richardson, 1991) • Physical functioning, e.g., short-form health survey (SF-36) (Cuignet et al., 2019) • Bicycling skills (Thigpen, 2018)
Cognitive skills	• Educational level, professional status, age (Witte & Macharis, 2010) • Number of languages spoken (Kaufmann et al., 2017) • Ability to read a map and orient oneself in space (Kaufmann et al., 2017) • Driver's license) (Cuignet et al., 2019) • Usage of internet) (Cuignet et al., 2019) • Ability to consider moving farther than 50 km from home (Kaufmann et al., 2017)
Appropriation	
Mobility habits/experiences	• Frequency of usage of different transport modes) (Cuignet et al., 2019) • Number of regular activity places, and average number of trips per month (Cuignet et al., 2019)
Preferences/plans/attitudes	• Participants' attitudes regarding different aspects of different transport modes (e.g., speed, comfort, safety, commodity, ecology, etc.) (Cuignet et al., 2019) • Bicycling attitude (Thigpen, 2018) • Willingness to move to another region, to move abroad, to commute long distances, to commute weekly, to travel frequently on business, etc. (Kaufmann et al., 2017)

2.2 Movement: How People Are Mobile

Besides motility, it is also important to assess the complementary concept of movement, depicting the manifestations of mobility. Movement is defined as the everyday spatio-temporal patterns of an individual's mobility in their environment. Movement can be analyzed by three intertwined dimensions: spatial structure, temporal structure, and the nature of activities (**Figure 1**) (Chaix, Méline, Duncan, Jardinier, et al., 2013). Furthermore, movement determines when, where, and how people are exposed to physical (i.e., built and natural) and social environments (Chaix et al., 2012; Jankowska, Schipperijn, & Kerr, 2015; Perchoux et al., 2013; Stewart, Schipperijn, Snizek, & Duncan, 2017). In turn, movement is also influenced by the environment that surrounds individuals. The reciprocal effects between movement and daily environmental exposure, however, are not further considered in this chapter. Similarly to Pooley, Turnbull, and Adams (2005), our definition of movement refers to all travel undertaken on a temporary basis. This includes frequent and regular trips (such as the journey to work), as well as less regular but still frequent trips (to visit friends, to shop, and for other leisure activities), and trips undertaken only once or twice a year (such as visits to distant relatives).

Movement is a dynamic process that can be assessed in different ways. The classical way is to use single-occasion paper-and-pencil or online questionnaires that ask participants for their typical everyday movement at various levels of detail, such as the life-space questionnaire (Stalvey, Owsley, Sloane, & Ball, 1999) or travel diaries (Richardson, Ampt, & Meyburg, 1995). Moreover, movement can be assessed using interactive map-based questionnaires, such as the VERITAS tool used in Kestens et al. (2016). Recent studies increasingly have relied on the more objective sensor-based location sensing methods—most prominently, Global Positioning Systems (GPS)—in which participants wear sensors in custom-built devices or smartphones that continuously and unobtrusively track participants' locations (Chaix, 2018; Fillekes, Röcke, Katana, & Weibel, 2019; Hirsch et al., 2014). Self-reports typically reflect generalized information about individuals' habitual movement that often also includes additional semantic information about travel purpose or transport modes, while GPS devices collect information on movement behavior in the daily lives of participants at high spatio-temporal resolutions (Fillekes, Röcke, et al., 2019; Schipperijn et al., 2014). Often 1 week of GPS data are recorded to assess an individual's habitual movement, assuming that the majority of the movement patterns are repeated on a weekly basis (Cornwell & Cagney, 2017; Giannouli et al., 2016; Kestens et al., 2016; Schmidt, Kerr, Kestens, & Schipperijn, 2018). Some GPS studies have shown, however, that a minimum of 14 days of GPS data are needed to obtain a stable measure of an individual's activity space (Stanley, Yoo, Paul, & Bell, 2018; Zenk, Matthews, Kraft, & Jones, 2018) and people's movement habits may change to a greater extent than expected (Burkhard, Ahas, Saluveer, & Weibel, 2018).

Movement is a multi-dimensional concept, and a plethora of different movement indicators is used in the health and aging literature to assess an individual's movement patterns (Fillekes, Giannouli, Kim, Zijlstra, & Weibel, 2019; Perchoux et al., 2014). Commonly used movement indicators are presented in **Table 2**, classified along the three major dimensions spatial structure, temporal structure, and nature of activities, similarly as suggested in Fillekes et al. (2018, Fillekes, Giannouli, et al. 2019). Each dimension consists of further sub-dimensions that group indicators with similar characteristics.

Table 2: Exemplary movement indicators used in health/aging research classified into dimensions and sub-dimensions according to the movement characteristics they represent.

Dimension	Indicators
Spatial structure	
	Frequency of mobility
	• Number of out-of-home locations (Montoliu, Blom, & Gatica-Perez, 2013)
	• Number of trips (Brusilovskiy, Klein, & Salzer, 2016; Saeb, Lattie, Schueller, Kording, & Mohr, 2016)
	Extent of mobility
	• Area of activity space (Brusilovskiy et al., 2016; Hirsch et al., 2014)
	• Average distance from home (Cornwell & Cagney, 2017; Giannouli, Bock, & Zijlstra, 2018)
	• Distance traveled (Brusilovskiy et al., 2016)
	Geometry of activity space
	• Elongation of activity space (Perchoux et al., 2014)
	• Importance of residential neighborhood with respect to entire activity space (Perchoux et al., 2014)
	• Clustering of activities (mono vs. poly-centricity) (Hasanzadeh, 2019)
Temporal structure	
	Duration of mobility
	• Travel duration (Brusilovskiy et al., 2016)
	• Time out-of-home (Brusilovskiy et al., 2016)
	• Ratio between travel time and duration spent in locations (Dijst & Vidakovic, 2000; Susilo & Dijst, 2009)
	Timing/temporal rhythm
	• Movement activities in the morning vs. the evening (Fillekes, Giannouli, et al., 2019)
	• Movement activities at weekends and weekdays (Kaspar, Oswald, Wahl, Voss, & Wettstein, 2015)
	• Distance from home as a function of time (Shoval et al., 2011)
	Variability
	• Day-to-day overlap in activity space (Fillekes, Giannouli, et al., 2019)
	• Speed variance (Saeb et al., 2016)
	• Entropy in locations (Saeb et al., 2016)
Nature of activity	
	Activity diversity
	• Number of uniquely visited locations (Brusilovskiy et al., 2016)
	• Number of different types of locations visited (Perchoux et al., 2014)
	• Trip purpose / destination (e.g., work-related, recreational, social) (Bohte & Maat, 2009; Perchoux et al., 2019)
	• Trip accompaniment (Kestens, Wasfi, Naud, & Chaix, 2017)
	Transport mode
	• Travel duration using active (non-motorized) vs. passive (motorized) transport modes (Fillekes, Röcke, et al., 2019)

The schematic depiction in **Figure 2**serves to illustrate how the movement patterns of two different individuals over 2 days can be described using indicators reflecting differences in the movement dimensions introduced above. Individual A on average has a smaller activity space (spatial structure: extent) and more consistent activity space (temporal structure: variability), uses mostly active transport modes (nature of activity: transport mode), and visits an average of three locations per day (spatial structure: frequency). Individual B, in contrast, has more variability in the size of activity space, uses only motorized transport modes, and visits on average a lower number of locations.

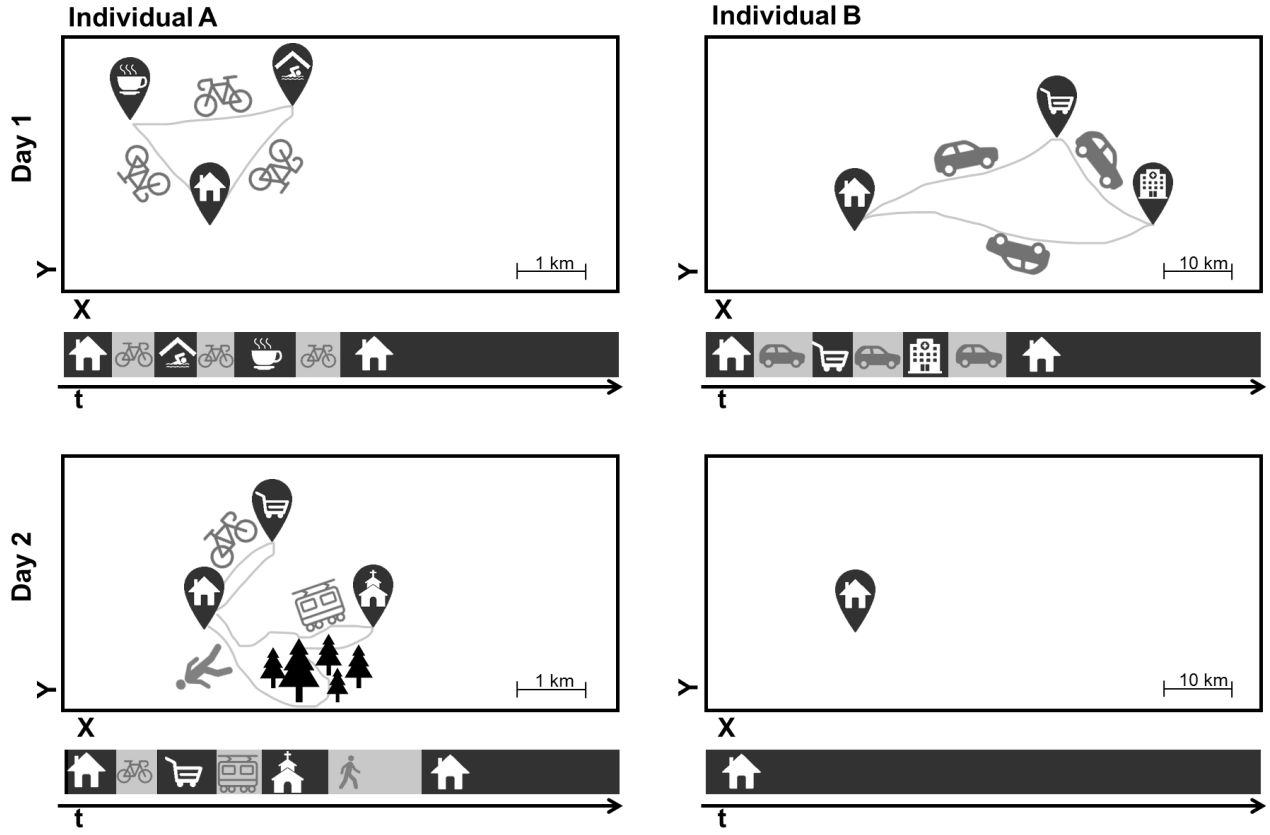

Figure 2: Schematic depiction contrasting spatial (maps, X/Y) and temporal (barcode, t) view of the movement of two days of two individuals.

3 Conceptual Model Linking Mobility and Personality with Healthy Aging

An increasing number of studies have moved toward adopting more comprehensive conceptualizations of mobility and personality, respectively. Spatial science researchers suggest to integrate assessments of a person's stable motility with assessments of the dynamic construct of movement (Cuignet et al., 2019; Kaufmann, 2002; Shareck et al., 2014). Similarly, personality psychologists propose to complement the more commonly investigated relatively enduring personality traits with dynamic situation-dependent state-level fluctuations of personality (Baumert et al., 2017; Fleeson, 2004; Fleeson, Malanos, & Achille, 2002). The conceptual model (**Figure 3**) shows the potential causal pathways linking these more comprehensive conceptualizations of mobility and personality, and healthy aging. Healthy aging is defined as the "process of developing

and maintaining the functional ability that enable well-being in older age" (WHO, 2015, p. 28). The intrinsic capacity of an individual (i.e., the composite of all physical and mental capacities), the relevant environmental characteristics and the interaction between the two constitute and shape an individual's functional ability. For this chapter, we focus on the three healthy aging "outcomes" independence, active living and social participation, which are crucial domains of functional ability enabling older adults' well-being and consequently are important outcomes of healthy aging (Kestens et al., 2016; Oswald et al., 2007; Schalock et al., 2008; Webber, Porter, & Menec, 2010; WHO, 2015).

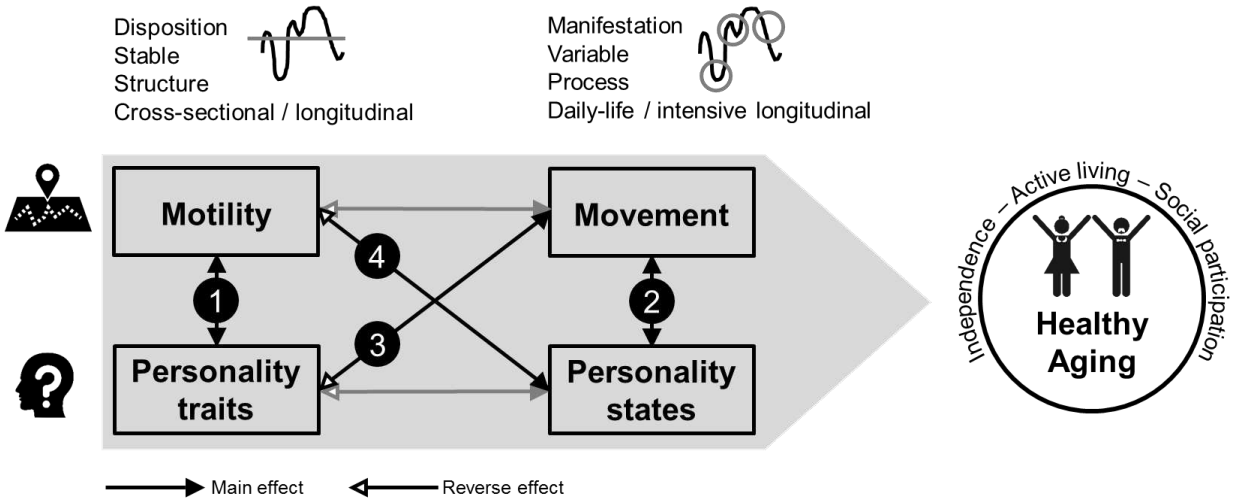

Figure 3: Conceptual model illustrating the links between the components of mobility (motility and movement) and the components of personality (personality traits and states) for healthy aging. The keywords at the top of the figure are contrasting properties that characterize the constructs, further illustrated by small pictograms. The grey links are more frequently studied links and not dealt with in detail in this paper.

The model positions the two relatively temporally stable constructs of motility and personality traits at one end of the spectrum (left), while movement and personality states, more variable over time, are placed at the other end (right). Both motility and personality traits are reflecting the dispositional tendencies of a person with respect to the corresponding domain. With exception of rare disruptive changes (e.g., change of residence), many of the motility dimensions and personality traits are relatively enduring and show slow changes over time (Roberts, Wood, & Caspi, 2008). Cross-sectional studies typically examine whether specific motility dispositions (Cuignet et al., 2019) or certain personality traits (e.g., conscientiousness, emotional stability, or openness) (Sutin et al., 2016; Weston, Hill, & Jackson, 2015) lead to better health outcomes. Longitudinal designs are used more often in personality than in motility-related research, often to study stability or developmental change in personality traits (Roberts et al., 2008; Terracciano, Stephan, Luchetti, & Sutin, 2018). Motility and personality traits can be seen as part of an individual's functional ability (Sallis et al., 2006; WHO, 2015). Thus, they constitute important resources influencing an individual's healthy aging and well-being. Moreover, they are key structural determinants for an individual's daily life movement and personality states.

Movement and personality states describe the actual manifestations of mobility and personality, respectively. Both movement and personality states are more context- specific and time-dependent

than motility and personality traits, and thus more variable over short-term intervals (Baumert et al., 2017; Fleeson, 2004). Healthy aging research that involves the daily-life assessments of movement or personality states is still relatively novel. Recent technological developments (including the miniaturization of sensors) benefit assessment strategies such as intense (i.e., high sampling intervals) longitudinal methods including sensor-based (e.g., GPS), or self-reported ambulatory assessments to describe of an individual's typical behaviors or investigate within-person processes (Allemand & Mehl, 2017; Harari, Müller, Aung, & Rentfrow, 2017; Seifert, Hofer, & Allemand, 2018). Such assessments allow to study movement and personality states of individuals which contribute to reveal the degree of people's engagement in social activities, as well as the degree to which people live actively and independently. For example, duration of active traveling has been positively associated with older adult well-being (Chung et al., 2015; Huss et al., 2014) whereas negative associations were found between long daily commutes and well-being (Stutzer & Frey, 2008). Respective findings thus far speak to the importance of each construct to healthy aging and well-being.

Overall, the conceptual model postulates that causal pathways lead mainly from the rather stable (left) via the more variable (right) constructs to healthy aging (as indicated by the "main effect" arrows in **Figure 3**). Reverse effects (represented by respective arrows in **Figure 3**) are less pronounced and are discussed only marginally in this chapter. Bidirectional pathways are expected for constructs that are aligned on the same level (e.g., between personality traits and motility). Regarding the link between mobility component and healthy aging, we would like to refer the reader to Cuignet et al. (2019). The links between personality components and healthy aging are discussed in several chapters in this book. In the remaining sections, we discuss the between-domain links and how they relate to healthy aging (numbers 1 to 4 in **Figure 3**). For each link, a subsection will be devoted to discussing existing theoretical frameworks and empirical findings, as well as hypotheses for future research.

3.1 Motility, Personality Traits, and Healthy Aging

An individual's motility is expected to be associated with an individual's personality traits, and both constructs individually and in combination influence the individual's healthy aging process (no. 1 in **Figure 3**). First, regarding the access dimension of motility, personality traits may influence where people live, the characteristics of their surrounding environments and their access to environmental resources (Götz, Ebert, & Rentfrow, 2018; Jokela, Bleidorn, Lamb, Gosling, & Rentfrow, 2015). Individuals high in openness to experience and extraversion show greater tolerance for alternative lifestyles and ideas and therefore tend to reside in urban areas characterized by higher population densities and ethnic diversity (Rentfrow, Gosling, & Potter, 2008). According to the mechanism of self-selection or attraction people choose to reside in or visit a neighborhood that fits their personality. If the fit between personality traits and motility is good, a positive effect on an individual's psychological well-being is expected (Garretsen, Stoker, Soudis, Martin, & Rentfrow, 2018; Götz et al., 2018). Similarly, in environment-health research, this mechanism is called the selective residential bias: individual preferences for specific environment or behavior—partly driven by personality—influence the choice of residential location (Chaix, Méline, Duncan, Merrien, et al., 2013). This choice in turn influences their health. Extraverted people, for example, might be more likely to choose to live in environments that enable social interactions, in turn

promoting healthy aging. Second, regarding the competences dimension of motility, conscientiousness and openness are likely associated with a better physical and cognitive functioning (see Hill & Allemand, Chap. 1, this volume and Payne & Lohani, Chap. 11, this volume), which in turn influences the competences to be mobile, such as having a driver's license or a good physical fitness. Thereby, indirect positive impacts of personality traits are reflected in motility competences that are generally associated with an individual's sense of independence (Banister, 2018; De Vos, 2018; King et al., 2011; Rosso, Auchincloss, & Michael, 2011; Shliselberg & Givoni, 2018). Third, regarding the appropriation dimension of motility, it could be hypothesized that extraverted and open people have attitudes oriented toward active and public transport modes (Sallis et al., 2006).

Conversely, motility may have an influence on personality traits over time, as the environment they are exposed to and their mobility experiences might act on individuals' underlying personality traits (Pooley et al., 2005). In line with this idea, Zimmermann and Neyer (2013) observed that students going abroad during their studies showed increased levels of openness and extraversion and decreased levels of neuroticism—changes that are generally represented as beneficial for healthy aging (e.g., Luchetti, Terracciano, Stephan, & Sutin, 2016).

3.2 Movement, Personality States, and Healthy Aging

Technological advances have recently made possible the study of personality states in daily life with different methods that can be summarized under the term ecological momentary assessment (see Demiray et al., Chap. 8, this volume; Jackson & Beck, Chap. 7, this volume). This includes using mobile phone apps for self-reporting or observational methods including audio and video recording, or analyzing online social network data or mobile phone call data (Allemand & Mehl, 2017; Toole, Herrera-Yaque, Schneider, & Gonzalez, 2015). Combining these methods with location-sensing technologies holds the potential for understanding how personality states and movement patterns influence each other, and further impact health (see no. 2 in **Figure 3**).

To our knowledge, the sole study investigating the interface between movement and social behaviors is the one of Alessandretti et al. (2018). They found that the size and stability of activity space over time are related to the size and stability of an individual's social network. They suggest that these manifestations of movement are explained by similar dispositions in the personality traits of extraversion, openness, and neuroticism. Another potential explanation is that individuals who have a higher number of contacts have to travel greater distances in order to maintain their social contacts. Older adults who manifest many extraverted and open states, and who engage with a large activity space are likely to be more independent and engaged in social participation (c.f. Viljanen, Mikkola, Rantakokko, Portegijs, & Rantanen, 2015). Conversely, traveling using active and public means of transport might stimulate open and extraverted personality states that have reinforcing beneficial effects on healthy aging.

3.3 Personality Traits, Movement, and Healthy Aging

Research using personality traits to explain individuals' differing movement patterns is more widespread and comes to the following conclusions (see no. 3 in **Figure 3**): More open, extraverted and emotionally stable people have higher numbers of visited locations, larger distances travelled, and show less routine behavior than individuals with lower propensities in these traits (Alessandretti

et al., 2018; Chorley et al., 2015; de Montjoye et al., 2013). Personality traits indirectly influence healthy aging, by triggering movement patterns positively associated with social participation, active living and well-being. The same traits that are known to shape an individual's engagement with physical activity and that are generally known to be associated with healthy behaviors—i.e., high levels of extraversion, openness, conscientiousness and a low level of neuroticism (e.g., Bogg & Roberts, 2004; Sutin et al., 2016)—are likely to foster the use of more health-beneficial active transport modes (e.g., walking and bicycle) and less motorized ones, known to negatively affect momentary well-being (Seresinhe, Preis, MacKerron, & Moat, 2019). However, using personality traits to explain patterns of movement is still a recent endeavor. Future research should link personality traits to specific types of movement patterns, which in turn may promote or impair the process of healthy aging.

Besides the study of the indirect effects of personality traits on healthy aging via movement, the study of personality traits as potential moderators between movement and healthy aging predictors offers an exciting field of research. One could, for example, evaluate whether open or extraverted individuals experience greater well-being after moving through a range of public locations. If this was the case, these traits may explain to what degree an individual takes advantage of the possibility to engage with the environment offered through the visited locations, and thus has beneficial effects on their well-being and healthy aging.

3.4 Motility, Personality States, and Healthy Aging

Motility offers interesting insights into how an individual's mobility context influences their manifested personality states (see no. 4 in **Figure 3**). Besides a direct impact of motility on healthy aging, such as living in a residential neighborhood with good accessibility to transport and various facilities having positive impacts on subjective well-being (Liu, Dijst, & Geertman, 2017), motility might have indirect impacts on healthy aging by fostering certain health-beneficial personality states. For example, older adults living in neighborhoods characterized by good walkability and opportunities for social engagements may show more extraverted and open personality states in their daily lives, and in turn potentially higher levels of well-being. In the opposite, living in a more deprived and unsafe neighborhood may lead to more neurotic states such as anxiety and might consequently decrease well-being. Though studying motility and personality states in isolation already may uncover some healthy aging relevant relationships, integrating these constructs with their respective counterparts (i.e., movement and personality traits) could offer a higher potential to understand the mechanisms at play in shaping healthy aging.

4 Additional Comments on the Conceptual Model

This section addresses how to combine comprehensive views of both mobility and personality in healthy aging research. Furthermore, we attempt to show how this combination can help to identify populations at risk for adverse outcomes based on their mobility and personality profiles, and to tailor interventions that simultaneously target the more structural and variable constructs to have maximal health-beneficial effects for aging.

Including mobility into models of personality and healthy aging might explain why older adults with similar personality traits might show different health-beneficial personality states. Some people

might be trapped in a deprived neighborhood and are constrained by their accessibility or mobility competences, and consequently show little movement, which results in less healthy personality states. By contrast, people who can move from their residence to another neighborhood that better fits their personality might be in better health. Moreover, motility might help to explain why an extraverted individual might show introverted states when traveling by train; namely, the person might simply be not accustomed to the use of public means of transport. Investigating whether specific motility-movement configurations are supportive for certain personalities or foster health-beneficial personality states could help promote healthy aging. In this logic, the suggestion to vary the daily travel itineraries would be appropriate for a person high in openness and extraversion but inappropriate for a person low on the respective traits. As older adults generally become less mobile in terms of both motility and movement, their residential neighborhood derives a higher symbolic and contextual importance (Vallée, Cadot, Roustit, Parizot, & Chauvin, 2011). Hence, achieving a good fit between personality and residential neighborhood is even more important. Research along these lines might help uncover how to design environments supportive of healthy aging taking into account individuals' preferences and needs derived from their personality profiles (Götz et al., 2018; Rosso et al., 2011).

Including personality into mobility-healthy aging research might contribute to explaining why older adults with similar mobility potentials manifest different movement behavior. People high in openness and extraversion, for example, may be more likely to travel beyond their residential neighborhoods because they might feel more at ease with using public means of transport. The resulting travel experience might expose older adults to different environments and allows them to access the goods and resources outside their neighborhood. These are behaviors that aid the promotion of healthy aging by fostering independence, active lifestyles and social participation. Tailored interventions targeting older adults without a driver's license, who also happen to be low in openness and extraversion, might consist of organized age-specific transport facilities to create a more familiar setting, as opposed to public transport (Viljanen et al., 2015). Moreover, individual differences in personality traits cause different desires and needs for movement (Chorley et al., 2015; Götz et al., 2018; Jokela et al., 2015; de Montjoye et al., 2013).

Exploring the different components of both mobility and personality is also relevant with respect to different temporal scales of analysis: Motility and personality traits might be more relevant for predicting global quality of life and well-being, as they are closely linked with an individual's intrinsic capacities. Whereas movement and personality states might lend themselves better to the study of the more short-term subjective well-being and its fluctuations. Thus, future research should investigate how motility and personality traits help explain an individual's momentary well-being. For example, individuals might feel uncomfortable traveling with public means of transport if their mobility and personality resources do not meet the activity's requirements (e.g., being familiar with using public transport modes, and having open, and extraverted personality traits). Knowing that an individual is low on the openness spectrum and feels uncomfortable in new situations, strategies could be developed to help familiarize the individual with the public transport system through an online tutorial to empower them to navigate in public transport with greater ease (i.e., improving the individual's motility). A better understanding of the causal pathways linking all these constructs to healthy aging would result in public health interventions that are more efficient by focusing on intervening on the constructs that have optimal direct and indirect positive effects on healthy aging

outcomes, or by targeting a specific sub-population for which positive effects of an intervention are to be expected.

5 Challenges and Future Directions

Assessing the multidimensional nature of motility, movement, personality traits and states is important because the individual dimensions of each construct are likely to have complementary and differential effects on healthy aging. When it comes to assessing movement, however, more research is required to identify the fundamental underlying dimensions of movement (Fillekes, Giannouli, et al., 2019; Perchoux et al., 2014). There are also technical issues still remaining. For instance, despite a large number of recent studies that are based on GPS assessments, limited battery life, as well as dealing with erroneous or missing GPS signal in and around buildings, still pose problems (Kerr, Duncan, & Schipperjin, 2011). Lastly, also more consensus on how to quantitatively operationalize motility will help the field to advance (Cuignet et al., 2019; Flamm & Kaufmann, 2006; Kaufmann et al., 2017). Regarding the directionalities of the causal pathways between the constructs, many of the examples are leading from the dispositions via the manifestations to the healthy aging outcomes. However, the potential for reverse causality should also be further investigated using prospective longitudinal studies or quasi-experimental designs. Movement and personality states that foster independent and active living, and social participation, certainly contribute to maintaining a positive well-being as one enters older adulthood. Conversely, health status is also expected to condition what types of movement and personality states are manifested. Furthermore, the proposed conceptual model focused on mobility and personality. However, other factors such as socioeconomic conditions, political and cultural circumstances may have an impact on healthy aging as well and may interact with mobility and personality (Pooley et al., 2005; Sallis et al., 2006).

A next step to an understanding of the mechanisms determining how mobility and personality impact on healthy aging would entail the formulation and empirical testing of hypotheses on the potential mediating and moderating effects of each dimension of the mobility and personality components on each other as well as on healthy aging outcomes. To answer questions exploring the interplay of motility, movement, personality traits, and states, new types of study designs are needed that combine comprehensive measurements of the stable constructs with intensive bursts of daily-life assessments of the more fluctuating constructs. Subsequently, statistical methods such as longitudinal structural equation modeling (Little, 2013) and multilevel modeling (Bolger & Laurenceau, 2013) might be helpful to test the validity of the conceptual model. Motility and personality traits are important resources determining what competences and environments older adults have at their disposal to engage in activities representing active and independent living, and engagement in social interaction. Healthy aging could for example be fostered by enhancing an individual's motility and therefore influencing an individual's healthy aging process via multiple pathways. Example health interventions could be targeted at improving access to transport facilities or to change people's attitudes towards active transport modes by promoting its ecological and healthy aspects. Such interventions directly positively influence physical health, but also indirectly positively act on healthy aging by facilitating more out-of-home movements, which in turn stimulate open and extraverted personality states. Future research looking into the relations between mobility,

personality, and healthy aging will help to further develop theory and reveal how healthy aging can be promoted based on individuals' mobility and personality.

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